Design, Analysis and Manufacturing of Multistage Evaporative Desert Cooling System

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Abstract. This research described the development of a test setup and performance evaluation of a Multistage Evaporative Desert Cooling System (MEDCS) (Cooling - Humidification - Cooling -Dehumidification) by considering the advantage of indirect evaporative system and overcoming the disadvantages of direct evaporative cooling system using copper tubes and Honey comb cooling pads. In this research the maximum performance in multistage evaporative cooling at 2450 rpm. The best parameters are found at this rpm are temperature 23.6 °C, relative humidity 63%, specific humidity 0.13 kg of water vapors/kg of dry air, dry bulb temperature 38 °C, dew point temperature 10 °C, wet bulb temperature 13 °C and enthalpy 75 kJ/kg at average consumption of 8.07 L/h. In multistage evaporative cooling, after reached required relative humidity and specific humidity, by switching off direct evaporative cooling system we can maintain same room temperature by running indirect evaporative cooling technology without any addition of moisture.

Keywords: MEDCS · DEC · IEC · Copper tubes · Honey comb cooling pads · DBT · WBT · DPT · Humidity and water

1 Introduction

World is continuously trying to formulate new one. Somebody tries to find new one and tries to transform an ordinary one to implement a technology. This is the upshot of population growth and increase in the comfort of living which is directly proportional to energy consumption. In practice power scarcity is also occurred. These difficulties are corrected by modification by Evaporative Cooling Technology.

Energy request worldwide for structures cooling has expanded forcefully over the most recent couple of many years, which has raised worries over consumption of energy assets and adding to an unnatural weather change. Current energy request gauges remains at somewhere in the range of 40 and half of all out essential force utilization. In hot atmosphere nations, the most noteworthy portion of building energy use is primarily because of space cooling utilizing conventional HVAC frameworks. For instance, in the

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Middle East, it represents 70% of building energy utilization and around 30% of all out utilization. These days, a structure cooling has become a need for individual's life and assumes an essential part in guaranteeing indoor solace levels. Subsequently, improving the productivity of cooling innovations are basic, especially ones that have the potential, for example elite, low force utilization [7]. The evaporative cooling (EC) innovation depends on warmth and mass exchange among air and cooling water. Direct evaporative cooling (DEC) depends on mechanical and warm contact among air and water, while Indirect evaporative cooling (IEC) depends on warmth and mass exchange between two floods of air, isolated by a warmth move surface with a dry side where just air is cooling and a wet side where both air and water are cooling. Both DEC and IEC are described by high energy effectiveness yet additionally by critical water utilization rates. On account of IEC innovation, on the dry side of the warmth move surface (dry surface), is streaming the essential (or item) air that is chilling off. On the wet side of the warmth move surface (wet surface), is streaming the optional (or working) air in blend with water [8].

Direct Evaporative Cooling (Dec) - This framework is the most established and the least complex kind of evaporative cooling in which the open air is carried into direct contact with water, for example cooling the air by changing reasonable warmth over to dormant warmth. Shrewd methods were utilized huge number of years prior by old human advancements in assortment of setups, some of it by utilizing pottery container water contained, wetted cushions/canvas situated in the sections of the air. Direct evaporative coolers in structures shift regarding operational force utilization from zero capacity to high power utilization frameworks. DEC frameworks could be isolated: Active DECs which are electrically controlled to work and Passive DECs that are normally worked frameworks with zero force utilization. DEC is just appropriate for dry and hot atmospheres. In sodden conditions, the overall dampness can reach as high as 80%, such a high mugginess isn't reasonable for direct flexibly into structures, since it might cause distorting, rusting, and buildup of vulnerable materials [7].

Indirect Evaporative Cooling (Iec) - The essential thought of the backhanded evaporative coolers is cooling by diminishing air reasonable warmth without changing its dampness, which is an unmistakable favorable position over DEC frameworks. A typical IEC unit involves: a warmth exchanger (HX), little fan, siphon, water tank, and water circulation lines. Roundabout evaporative coolers are grouped into: Wet-bulb temperature IEC frameworks and Sub wet-bulb temperature ICE frameworks [7].

2 Literature Review

The accompanying examination sees are considered for accomplish our goal as follows 1) T. Ravi Kiran et al. - In his Study they has zeroed in on energy prerequisites of the world and further added that Energy utilization everywhere on the world is expanding quickly and there is a squeezing need to create approaches to monitor energy for people in the future. Scientists are compelled to search for sustainable wellsprings of energy and approaches to utilize accessible wellsprings of energy in a more proficient manner. Traditional refrigeration based fume pressure cooling frameworks devour an enormous part of electrical energy delivered generally by petroleum derivative. An epic dew point evaporative cooler (DPEC) can reasonably cool the approaching air near its dew point temperature. In this paper achievability of DPEC framework is explored for different Indian urban areas for places of business during day time. Initially the climate information of various urban communities of India is utilized to discover the appropriateness of dew point innovation for Indian structures by assessing the cooling limit of the cooling framework for every city. Also energy sparing capability of the dew point cooling framework w. r. t. to the regular pressure based cooling framework for various urban communities of India is assessed. 2) J.K. Jain et al. - The evaporative cooler uses perhaps the most established guideline of cooling known to Man, cooling of air by the dissipation of water. It is the most well-known type of house hold cooling found in bone-dry zones. The notoriety of evaporative cooling in such territories is because of its moderately low starting expense and operational expense contrasted with refrigerated cooling. Regular direct evaporative coolers comprise of a water store, a siphon that draws water from the supply and releases it through shower spouts straightforwardly into the air stream or through the cooling cushions. Present days the vast majority of the structures and workplaces utilize traditional cooling frameworks which depend on fume pressure refrigeration framework. These frameworks devour generous force and they might be unsafe to climate moreover. In agricultural nation like India, larger part of populace rely upon minimal effort cooling gadgets, for example, direct evaporative cooler. In this manner it is a lot of expected to create improved/more proficient coolers. A few specialists have made endeavour to create evaporative coolers by method of adding/adjusting plans. [2], they have brought up that in the districts where wet bulb temperature is low, two phase evaporative cooling framework, which joins roundabout and direct evaporative cooling offers energy and cost sparing potential. Discovered that most zones (especially northern area) of India where the wet bulb temperature is as a rule underneath 25°C, roundabout framework can accomplish comfort conditions like refrigerated frameworks. Also the solace offered by backhanded evaporative framework is better than that accomplished by direct evaporative framework. He expressed that when evaporative cooling innovation is assessed as an energy protection measure as opposed to the sole wellspring of cooling, the open doors for application become boundless. He found that the coefficient of execution of the consolidated evaporative cooling framework was at any rate 20% more prominent than those accomplished while utilizing either the aberrant evaporative cooling or direct evaporative cooling framework alone. He broke down the capability of circuitous evaporative cooling in each climatic condition. A focal cooled working through cutting edge evaporative cooling frameworks. He assessed the exhibitions of cellulosic cushions made out of Kraft and NSSC creased papers in three woodwind sizes, tentatively. He introduced their examination dependent on a few phase evaporative coolers, endeavored to contemplate the regenerative kind warmth exchanger, which uses tank water to additional cool the air in second stage. In the current work a warmth exchanger has been added to coordinate evaporative cooler. The regenerative evaporative cooler has been created and tried under Indian climatic conditions. Execution of regenerative framework has been assessed as far as by and large adequacy and COP. 3) Chuck Kutscher - The utilization of regular evaporative cooling has quickly declined in the United States regardless of the way that it has high potential for energy reserve funds in dry atmospheres. Evaporative frameworks are extremely serious as far as first cost and give critical decreases in working energy use, just as pinnacle load decrease benefits. Huge market obstructions, for example, the expense of the model evaporative cooling frameworks and purchaser impression of evaporative coolers being not able to keep up comfort conditions, actually remain and can be tended to through improved frameworks joining, including the accompanying: 1) Innovative segments, 2) Better plan of gracefully pipes and dampers, 3) Identification of best atmospheres for full cooling season comfort control and potential cutoff points forced by a blustery season, 4) Development of utility associations to turn out evaporative cooling framework plan boundaries for creation manufacturers. This examination researches the first of these methodologies, investigating inventive parts. The U.S. Branch of Energy (DOE) Building America research groups are examining the utilization of two promising new bits of private cooling hardware that utilize evaporative cooling as a portion of their framework plan. 4) Moien Farmahini Farahani, et al. - In His examination the aftereffects of an examination on a two-stage cooling framework have been considered. This framework comprises of a nighttime radiative unit, a cooling loop, and a backhanded evaporative cooler. During the night in summer, imperative chilled water for a cooling curl unit is given by nighttime radiative cooling and is put away in a capacity tank. During the following day, the water in the tank gives chilled water to the cooling loop unit and hot outside air goes through two-arranges: the cooling curl unit and a circuitous evaporative cooler. Three sources give optional air to the roundabout evaporative cooler. The sources are open air, the air leaving from the cooling loop, and the air leaving from the aberrant stage (regenerative). The examination has been led in climate conditions in the city Tehran. The outcomes got exhibit that the primary phase of the framework expands the adequacy of the circuitous evaporative cooler. Likewise, the regenerative model gives the best solace conditions. 5) R.H. Turne - In His examination he centers on possible utilizations of evaporative cooling (EC) and a related study of exploration prerequisites of EC as provided in private and little business structures. To set up this work, the writing in the field was evaluated and individuals dynamic in the field were reached. Sixteen suggestions are introduced and portrayed in the paper including institutional issues, suitable functions for EC frameworks, fundamental investigation and testing, legitimate applications, and equipment advancement needs. These suggestions speak to composite suppositions from the writing survey and telephone discussions as dissected by the writers. There are expected applications for EC frameworks and related exploration gives that are not completely perceived by most government organizations, service organizations, engineers, enterprises, chiefs, and the devouring public. Nonetheless, as energy costs ascend there will be expanding interest for operationally cheap cooling frameworks. Accordingly, data on the capability of EC frameworks could profit these gatherings. This paper centers on private and little business building utilizations of EC.

3 Objective of the Research

The main objectives of the research are 1. Dry Cold Air: We aim to reduce the moisture content and supplying cold dry air for human comfort. 2. Abatement sicknesses like Legionnaire's infection: Legionnaires' illness is a kind of pneumonia brought about by microscopic organisms. You typically get it by taking in fog from water that contains the microbes. The fog may originate from hot tubs, showers, or cooling units for huge structures. The microbes don't spread from individual to individual. 3. Size: We aim to reduce the size of the assembly by making it more compact. 4. Weight: The evaporative cooler system is too bulky. Its weight reduction is also one of the aims. It can be reduced by using polymers and fiber. 5. Power consumption and Cost: Cost is the biggest barrier in implementation of evaporative cooler. We aim to minimize it as far as possible and minimize power consumption. 6. Extended Usability: Till date evaporative cooler is limited in Afar region and industrial purposes. We aim to make it available for mass rural use as stated above in small capacities and low cost.7. Relative Humidity and Temperature: To maintain RH from 40% to 60% and Temperature from 22 °C to 27°C.

4 Working Principal of the Multistage Evaporative Desert Cooling

Stage 1 - 2: From state 1 the atmospheric dust and hot dry air enters through air filter, where dust is filtered and achieved clean hot dry air at state ***2. Stage 3 - 4:*** From state 3 the mild cold water pumped from the pump to honey comb pad. Where water enters through honey comb pad from top to bottom, while doing so the hot dry air mixed with cold water and reducing the temperature of the air. In this operation the moisture content in the air increased at state 7. But the mist air at state 7 is not good for human comfort because of increasing the humidity of the air and also causes ailments like Legionnaire's disease. To overcome this uncomfort we have to do dehumidification without decreasing the temperature of air. ***Stage 5 - 6***: The cold water from the honey comb pad pumped from the pump to heat exchanger and dehumidification unit. ***Stage 7 - 8***: The mist air enters at state 7 to heat exchanger and dehumidification unit (indirect). The heat exchanger is a combination of copper tubes and honey comb pad. The mist air while flowing through heat exchanger decreases the moisture content in the cold air by condensing the moisture on copper tubes and honey comb pads there by dehumidification process completed. The air is further cooled and reaches near to dew point temperature. There by the cold dry air is achieved at state 8 and this air is good for human comfort and health (Fig. 2).

5 Design and Theoretical Analysis

Design: The Multistage Evaporative Desert Cooling System consist of two heat exchangers equally spaced in which chilled water is supplied from the sump by using a high pressure submersible water pump of 40W. A fan of 18 W is fitted front side of the indirect heat exchanger, as shown in Fig. 1.

Assumption:

1) Inside diameter of the copper tube is 5 mm (As per available in market)
2) Gap between heat exchanger is 2 cm.
3) Ambient temperature is 38 °C.
4) Water temperature at starting of unit is 32 °C
5) Conductivity of Copper is 386 W/m^2

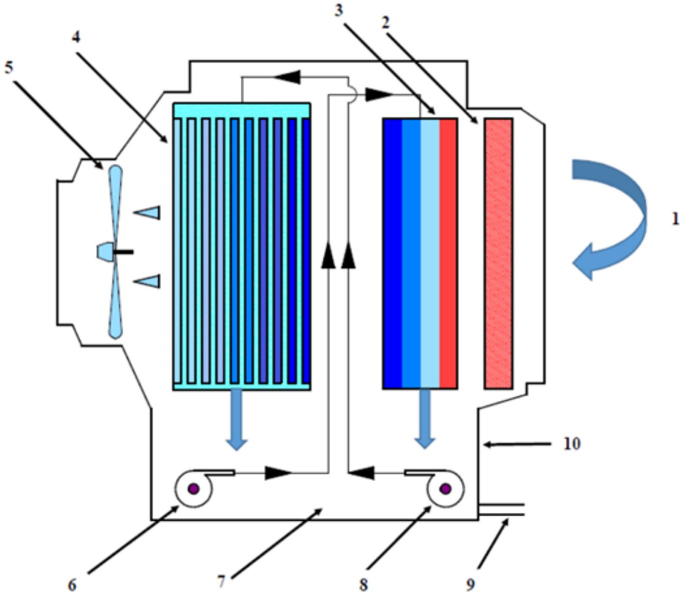

Fig. 1. Multistage evaporative desert cooling system. (Components - 1. Air Intake, 2. Air Filter 3. Honey comb pad 4. Heat Exchanger 5. Fan, 6. Submergible Water Pump, 7. Cement or Mud coated Water Sump, 8. Submergible Water Pump, 9. Drain or Out Let 10. Metal Body)

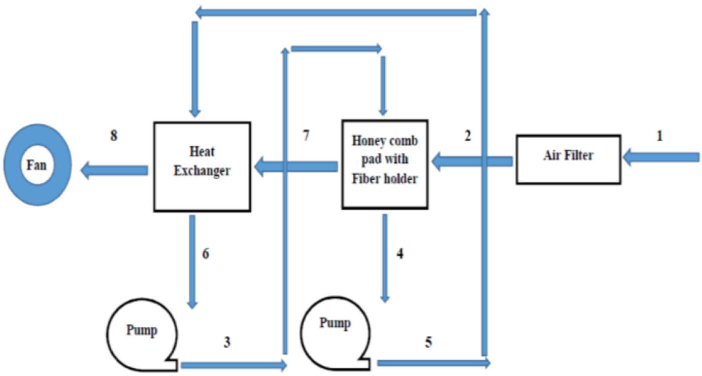

Fig. 2. Flow diagram of multistage evaporative desert cooling system

6 Results and Discussion

6.1 Detail of General Features, Specification of Pump and Product Dimension

General Features	Specification of Pump	Product Dimensions
For rooms up to - 10 Square ft, Engg. Plastic Fan Fan diameter (mm/inch) - 368/14 Speed Control- 3 Tank capacity (up to ltr.) – 70, Mosquito net / Dust filter – Yes, Cooling media – Aspen and cellulose (Direct and Indirect) Air Throw Distance (mt./ft.) - 10/33 Stand – Yes, Body – Sheet metal	Power Consumption:-18 W, Voltage:-AC 165 – 220 V/50 Hz, Outlet Nozzle Size:-½” Maximum, Head:-1.85 m, Maximum Flow: - 1100 L/H Powerful 3-speed motor and powerful fan Max Speed of Fan – 230 V / 3600 rpm Medium Speed of Fan- 220 V/3200 rpm Low Speed of Fan - 110V/2450 rpm	Length – 75 cm Breadth – 60 cm Height – 75 cm Product weight (kgs) – 15.5

6.2 Analysis of Room Temperature Using Direct Evaporative Cooling and Multistage Evaporative Cooling

Conditions: Room Area: 100 Square ft., Room Temperature: 38°C, Cooling Medium: Direct contact (Aspen Cooling Materials), Indirect Contact (Cellulose and Copper tube), Tank Capacity: 70 L, Water temperature at starting of unit is 33°C, Pump: Three Pumps Working (Table 1).

Table 1. Room temperature using direct evaporative cooling and multistage evaporative cooling

Speed/Time	Direct evaporative cooling			Multistage evaporative cooling		
	N = 3600 rpm	N = 3200 rpm	N = 2450 rpm	N = 3600 rpm	N = 3200 rpm	N = 2450 rpm
0	38	38	38	38	38	38
30	37	37.8	37.8	37.6	37.9	37.8
60	35	37.2	37.2	36.9	37.3	37
90	33	35	36.4	36.1	36.5	35.5
120	32.6	33.6	35.5	35	34	34

(*continued*)

Table 1. (*continued*)

Speed/Time	Direct evaporative cooling			Multistage evaporative cooling		
	N = 3600 rpm	N = 3200 rpm	N = 2450 rpm	N = 3600 rpm	N = 3200 rpm	N = 2450 rpm
150	32	32.3	34.1	34.2	33.5	33.5
180	31	31.1	33.1	33.5	32	32
210	29	29.4	31.7	32.1	30	30
240	28	28.3	30.5	31	29.5	29.5
270	27	27 .6	28.6	29.4	28.3	28.3
300		26.4	27.5	27.5	27	27
330		25.1	26.2	25.9	26.6	26.6
360			25	25.4	25.4	26.1
370			24.8	24.7	24.7	25.7
400			24.7		24.4	24.8
430					23.9	24.1
460						23.8
490						23.7
520						23.6
Avg Consumption of water	15.56 L/H	13.33 L/H	10.5 L/H	11.35 L/H	10.24 L/H	8.07 L/H

6.3 Comparison of Direct and Multistage Evaporative Cooling @ 3600 rpm

The Fig. 3 shows the comparison of direct and multistage evaporative cooling. As time increases the consumption of water vapors also increases there by decrease in room temperature. In direct evaporative cooling, the initial operating temperature is 38 °C and final operating temperature is 27 °C by consumption of 70 Lts of water in 4.5 h. The average consumption of water is 15.56 L/H. In multistage Evaporative cooling, the initial operating temperature is 38 °C and final operating temperature is 24.7 °C by consumption of 70 Lts of water in 6.16 h. The average consumption of water is 11.35 L/H. There by we can conclude that, in multistage evaporative cooling the average consumption of water decreased by 5.21 L/H, room temperature decreased by 2.3 °C and operating time increased by 1.66 h.

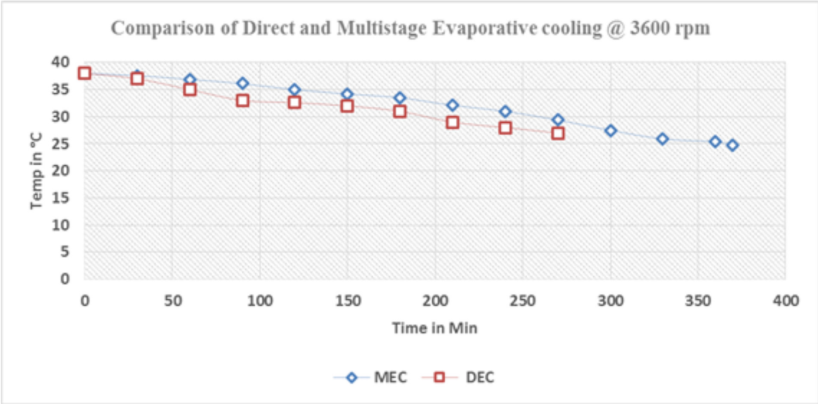

Fig. 3. Comparison of direct and multistage evaporative cooling @ 3600 rpm

The psychometric chart (Fig. 4) shows that the comparison of direct evaporative cooling system and multistage evaporative cooling system at 3600 rpm. The initial temperature at the beginning of experiment is 38 °C and corresponding relative humidity is 15%. The psychometric chart says that the relative humidity and temperature are higher in multistage evaporative cooling than direct evaporative cooling.

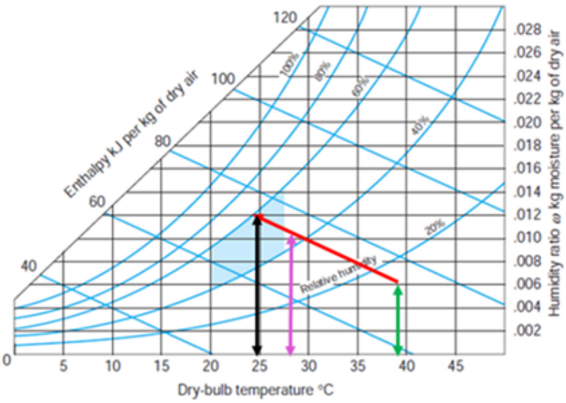

Fig. 4. Comparison of direct and multistage evaporative cooling @ 3600 rpm

6.4 Comparison of Direct and Multistage Evaporative Cooling @ 3200 rpm

The Fig. 5 shows the comparison of direct and multistage evaporative cooling.

As time increases the consumption of water vapors also increases there by decrease in room temperature. In direct evaporative cooling, the initial operating temperature is 38 °C and final operating temperature is 25.1 °C by consumption of 70 Lts of water in 5.25 h. The average consumption of water is 13.33 L/H. In multistage Evaporative cooling, the initial operating temperature is 38 °C and final operating temperature is 23.9 °C by consumption of 70 Lts of water in 6.83 h. The average consumption of water is 10.24 L/H. There by we can conclude that, in multistage evaporative cooling the average consumption of water decreased by 3.09 L/H, room temperature decreased by 1.2 °C and operating time increased by 1.58 h.

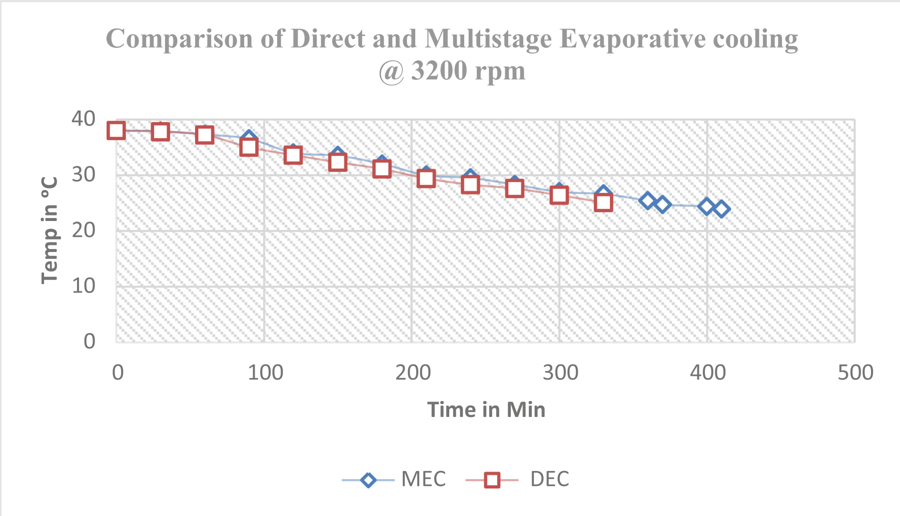

Fig. 5. Comparison of direct and multistage evaporative cooling @ 3200 rpm

The psychometric chart (Fig. 6) shows that the comparison of direct evaporative cooling system and multistage evaporative cooling system at 3200 rpm. The initial temperature at the beginning of experiment is 38 °C and corresponding relative humidity is 15%. The psychometric chart says that the relative humidity and temperature are higher in multistage evaporative cooling than direct evaporative cooling.

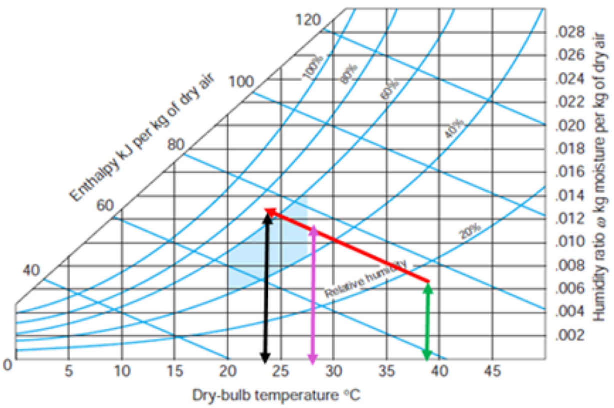

Fig. 6. Comparison of direct and multistage evaporative cooling @ 3200 rpm

6.5 Comparison of Direct and Multistage Evaporative Cooling @ 2450 rpm

The Fig. 7 shows the comparison of direct and multistage evaporative cooling.

As time increases the consumption of water vapors also increases there by decrease in room temperature. In direct evaporative cooling, the initial operating temperature is 38 °C and final operating temperature is 24.7 °C by consumption of 70 Lts of water in 6.67 h. The average consumption of water is 10.5 L/H. In multistage Evaporative cooling, the initial operating temperature is 38 °C and final operating temperature is 23.6 °C by consumption of 70 Lts of water in 8.66 h. The average consumption of water is 8.07 L/H. There by we can conclude that, in multistage evaporative cooling the average consumption of water decreased by 2.43 L/H, room temperature decreased by 1.1 °C and operating time increased by 1.99 h.

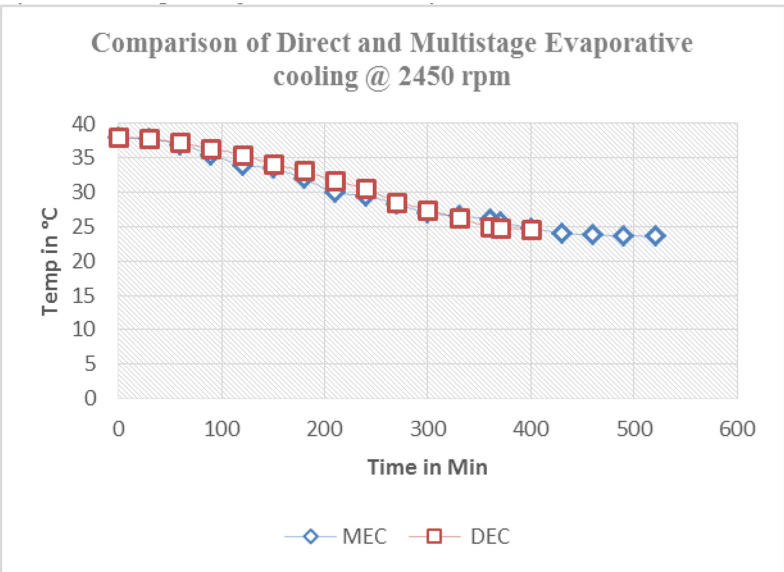

Fig. 7. Comparison of direct and multistage evaporative cooling @ 2450 rpm

The psychometric chart (Fig. 8) shows that the comparison of direct evaporative cooling system and multistage evaporative cooling system at 2450 rpm. The initial temperature at the beginning of experiment is 38 °C and corresponding relative humidity is 15%. The psychometric chart says that the relative humidity and temperature are higher in multistage evaporative cooling than direct evaporative cooling.

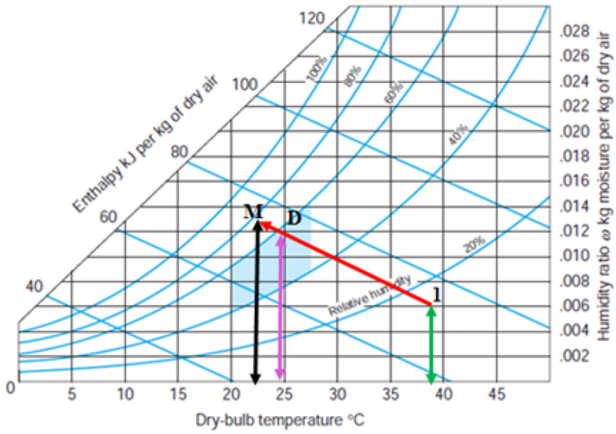

Fig. 8. Comparison of direct and multistage evaporative cooling @ 2450 rpm

6.6 Comparison of Direct Evaporative Cooling @ 2450 rpm, 3200 rpm and 3600 rpm

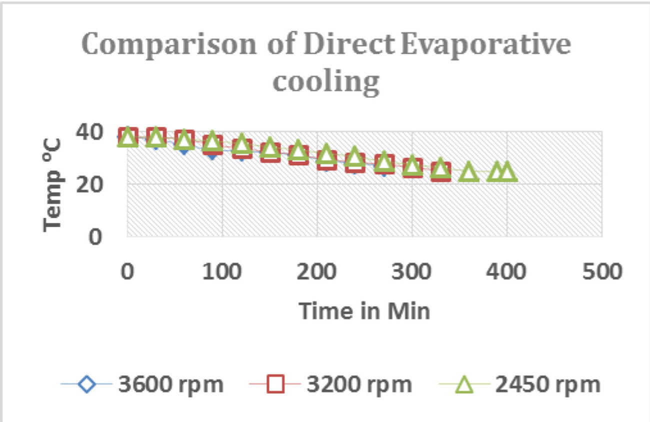

Fig. 9. Comparison of direct evaporative cooling

The Fig. 9 says that consumption of water and temperature with respect to time. As time increases the consumption of water vapors also increases there by decrease in room temperature. At 3600 rpm the initial operating temperature is 38 °C and final operating temperature is 27 °C by consumption of 70 Lts of water in 4.5 h. The average consumption of water is 15.56 L/H. At 3200 rpm the initial operating temperature is 38 °C and final operating temperature is 25.1 °C by consumption of 70 Lts of water in 5.25 h. The average consumption of water is 13.33 L/H. At 2450 rpm the initial operating temperature is 38 °C and final operating temperature is 24.7 °C by consumption of 70 Lts of water in 6.67 h. The average consumption of water is 10.5 L/H. From the above graph we can conclude that, by decreasing the speed of the cooling fan, the average consumption of water per hour decreases, room temperature decreases and operating time increases.

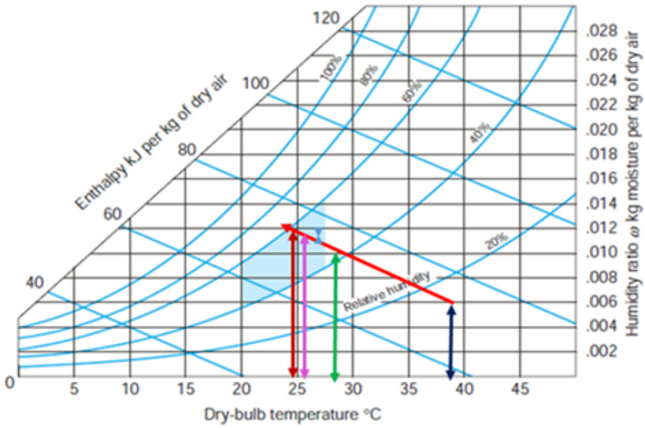

Fig. 10. Comparison of direct evaporative cooling

The psychometric chart (Fig. 10) says that the comparison of direct evaporative cooling at different speed. From the chart we can conclude that at low speed performance is maximum.

6.7 Comparison of Multistage Evaporative Cooling @ 2450 rpm, 3200 rpm and 3600 rpm

The Fig. 11 says that consumption of water and temperature with respect to time. As time increases the consumption of water vapors also increases there by decrease in room temperature. At 3600 rpm the initial operating temperature is 38 °C and final operating temperature is 24.7 °C by consumption of 70 Lts of water in 6.16 h. The average consumption of water is 11.35 L/H. At 3200 rpm the initial operating temperature is 38 °C and final operating temperature is 23.9 °C by consumption of 70 Lts of water in 6.83 h. The average consumption of water is 10.24 L/H. At 2450 rpm the initial operating temperature is 38 °C and final operating temperature is 23.6 °C by consumption of 70 Lts of water in 8.66 h. The average consumption of water is 8.07 L/H. From the above graph we can conclude that, by decreasing the speed of the cooling fan, the average consumption of water per hour decreases, room temperature decreases and operating time increases.

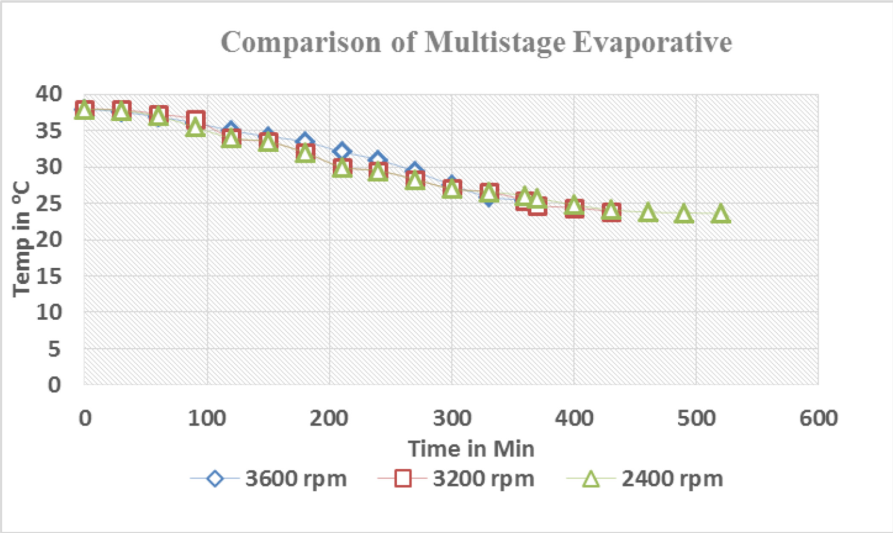

Fig. 11. Comparison of multistage evaporative cooling

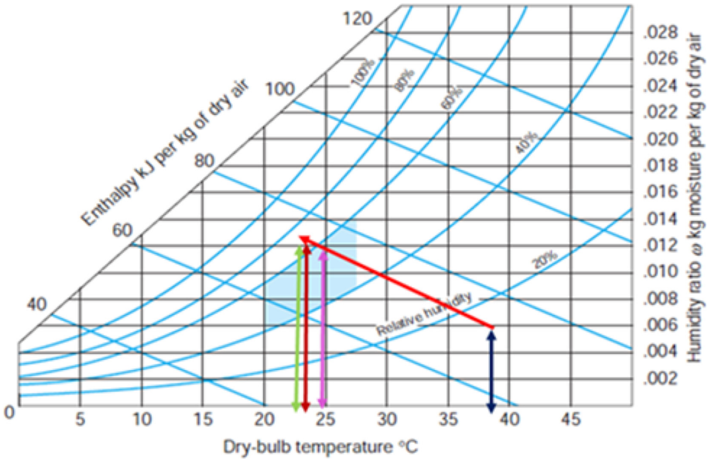

Fig. 12. Comparison of multistage evaporative cooling

The psychometric chart (Fig. 12) says that the comparison of multistage evaporative cooling at different speed. From the chart we can conclude that at low speed performance is maximum.

6.8 Comparison of Direct Evaporative Cooling and Multistage Evaporative Cooling @ 2450 rpm, 3200 rpm and 3600 rpm

From the Fig. 13 we can conclude that the performance of multistage evaporative cooling is effective than direct evaporative cooling. Multistage evaporative cooling in compare with direct evaporative cooling, the average consumption of water decreases, room temperature decreases and operating time increases. The best performance of multistage evaporative cooling at 2450 rpm (Fig. 14).

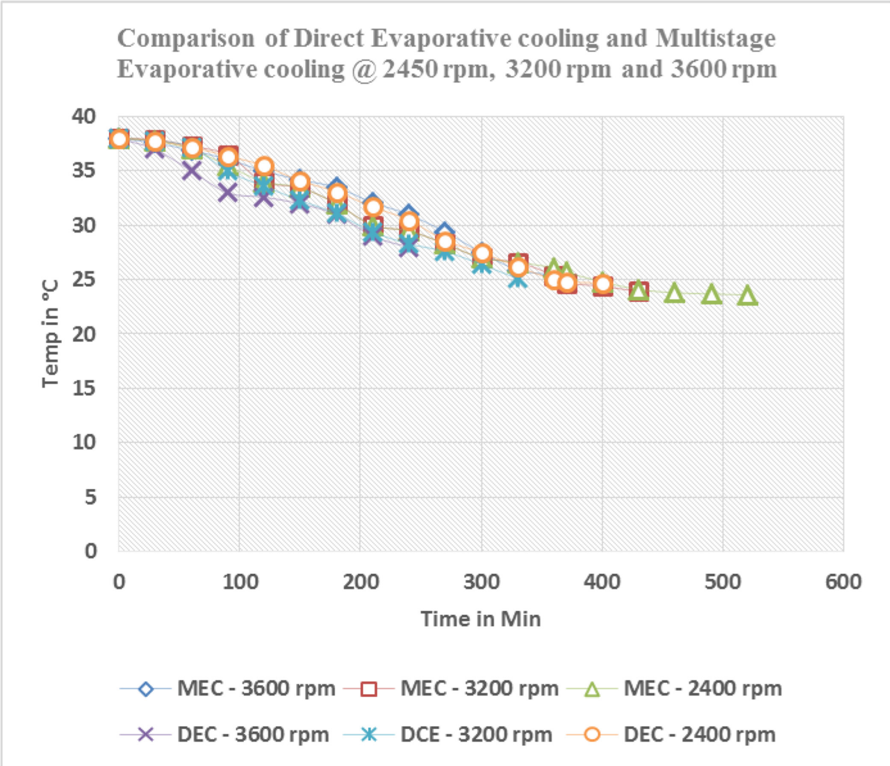

Fig. 13. Comparison of direct evaporative cooling and multistage evaporative cooling

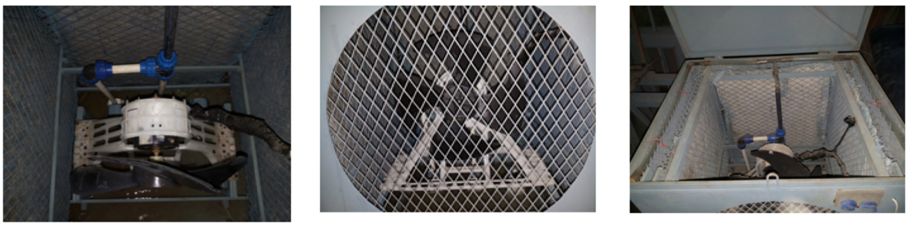

Fig. 14. Multistage evaporative desert cooling system

7 Conclusion

1. The product is a combination of direct and indirect evaporative cooling.
2. The maximum performance in direct evaporative cooling at 2450 rpm. The best parameters are found at this rpm are temperature 24.7°C, relative humidity 43%, specific humidity 0.12 kg of water vapors/kg of dry air, dry bulb temperature 38°C, dew point temperature 9°C, wet bulb temperature 15 °C and enthalpy 75 kJ/kg at average consumption of 10.5L/h.
3. The maximum performance in multistage evaporative cooling at 2450 rpm. The best parameters are found at this rpm are temperature 23.6 °C, relative humidity 63%, specific humidity 0.13 kg of water vapors/kg of dry air, dry bulb temperature 38 °C, dew point temperature 10 °C, wet bulb temperature 13 °C and enthalpy 75 kJ/kg at average consumption of 8.07L/h.
4. It's very difficult to control relative humidity and specific humidity in direct evaporative cooling.
5. In multistage evaporative cooling, after reached required relative humidity and specific humidity, by switching off direct evaporative cooling system we can maintain same room temperature by running indirect evaporative cooling technology without any addition of moisture.
6. By using multistage evaporative cooling system human comforts parameter are achieved. They are relative humidity ranges from 40%–60% and temperature ranges from 22 °C–27 °C.
7. Compare to conventional cooling systems, the multistage evaporative cooling system consumes less water and it is suitable for dry places.
8. Its continuously circulates fresh air to the living room but air conditioning circulates same air again and again.
9. It consumes less power than air conditioning system and it is suitable for remote places.
10. The weight of multistage evaporative cooling system is lesser than air conditioning system thereby transportation and installation is easy.

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